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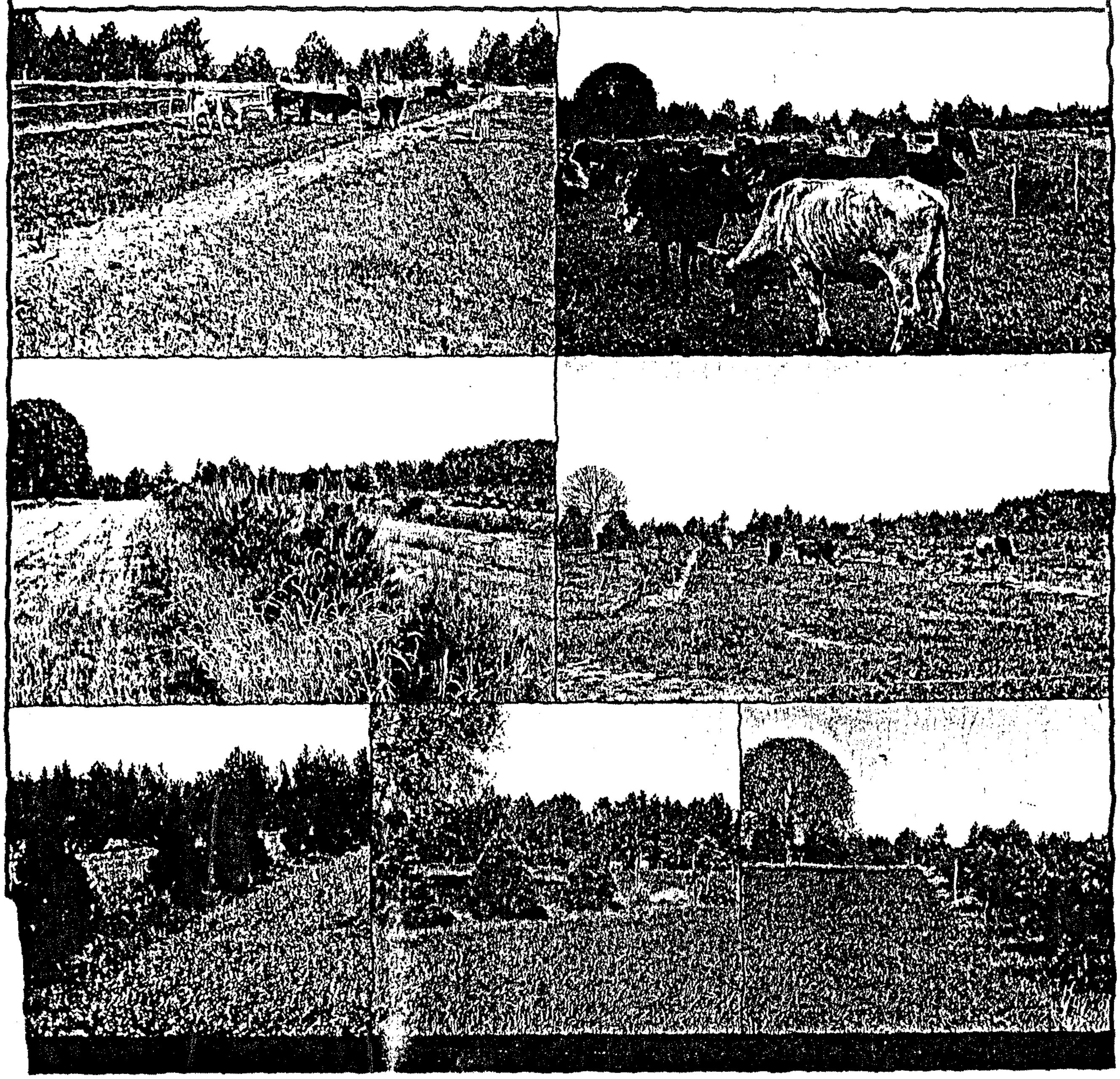

Operational Trials of a Scarifier-Seeder for Regenerating Ocala Sand Pine

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*ABSTRACT. Most harvested stands of Ocala sand pine (*Pinus clausa *var.* clausa *D. B. Ward) have been regenerated by direct seeding. An integrated system using a scarifier-seeder can reduce site disturbance, control spacing, and conserve seed. Modifications to this equipment to pack the soil over the seed, or to reduce the slope of the scarified spot did not improve stocking levels, but they did reduce seed movement. The alteration to reduce the slope of the scarified spot caused no mechanical problems and reduced seed displacement. Chopping to reduce competing vegetation greatly increased stocking levels, but there is little advantage to using a scarifier-seeder if sites must be chopped first. Criteria are needed for determining which sites are best suited to chopping and broadcast seeding and which to regenerate by scarifier-seeding.*

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Ocala sand pine (*Pinus clausa* var. *clausa* D. B. Ward) begins cone production at about age 5 years and has abundant annual crops (Barnett and McLemore 1965). The cones are predominantly serotinous and persist on the tree for many years, storing vast quantities of seed. Natural stands originated from the seed released by the serotinous cones following wildfires. A number of different systems for artificial regeneration of stands following timber harvesting have been tried. Because of the serotinous cone development, neither seed-tree nor shelterwood systems are suitable. Attempts have been made to effect regeneration using heat from the sun to open cones in logging slash, but this produced poorly stocked stands (Price 1973). Burning logging slash to release seeds has also been tried, but gave poor results because available cones were unevenly distributed and the fire destroyed many seeds (Cooper et al. 1959). Ocala sand pine can be planted, but due to its lack of true winter dormancy (Zelawski and Strickland 1973) survival is generally poor (about 60%) and variable (Burns and Hebb 1972, Hebb and Burns 1973). The most successful and economical system for regeneration has been clearcutting, site preparation, and direct seeding (Price 1973). With this method, seed are broadcast at a rate of 0.5 to 1.0 lb/ac following site preparation by chopping with a heavy, double-drum chopper. Research and experience has shown that some method of covering the seed with a layer of soil 0.25- to 0.75-in. thick will reduce seed predation and increase germination (Burns and Hebb 1972).

Although broadcast seeding has been the most successful system for regenerating Ocala sand pine, it is not an entirely satisfactory method. Regeneration failures are common during years having extended drought periods, which occur about 3 years out of 10. During years with adequate rainfall, some areas become overstocked and require precommercial thinning to prevent stand stagnation. In addition, there is no mechanism for spacing control, and the system is wasteful of seed, a factor that increases costs and reduces the area that can be regenerated with genetically improved seed.

In an effort to improve spacing, eliminate precommercial thinning, reduce costs, and conserve seed, a new technique using a scarifier-seeder was tested in 1983. This is an integrated approach that combines site preparation and seeding into one operation. The Bracke[1] machine used was equipped with rotating teeth, which turn over a spot of soil to create a pit-and-mound microsite, typically 18 in. wide × 4 ft long, with a 12-in.-deep pit (Damme 1988). Seed, which had been treated with Arasan and aluminum powder, were dropped on the mound portion of the scarified spot. Because it disturbs only a portion of the site, it is less deleterious physically than conventional site preparation systems, which scarify the entire area.

This combination method was very successful the first season when weather conditions were very favorable, but during the two dry years which followed many areas failed to regenerate adequately. Results from other species growing on similar soils show that packing the soil over the seeds can be beneficial (Winston and Schnieder 1977). The Ocala sand pine seeds were being dropped on the upper midslope region of the scalp—the most favorable microsite for germination (Parker 1972, Seabrook and Bax 1981, Clark 1984)—but because of the steep slope there was concern that seeds may have been washed away by rains before they could germinate. The objective of the first study reported here was to determine if modifications to the scarifier-

[1] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

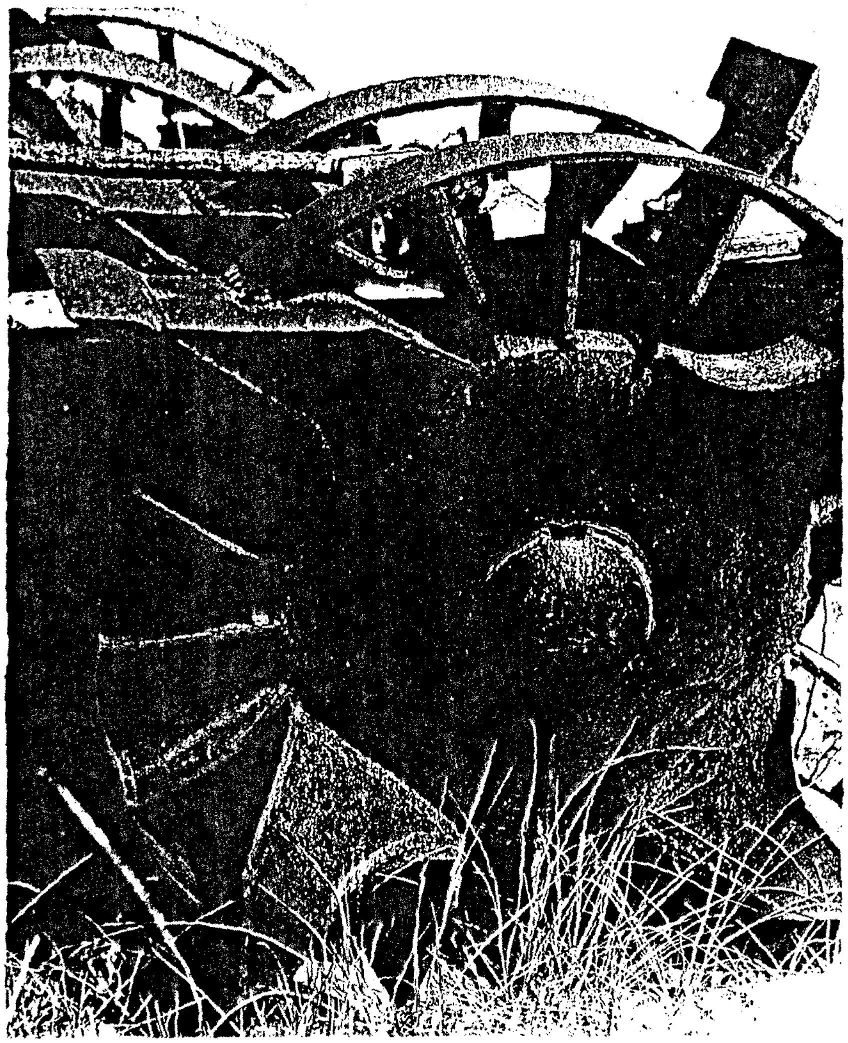

Figure 1. Modified scarifier teeth to create shallow patches.

seeding, to pack the soil over the seed, or to reduce the depth of the scalp, would improve stocking. Since competing vegetation can rapidly reduce soil moisture available for seed germination and seedling establishment, reduction of competition by chopping prior to the scarifier-seeder should be more successful in dry years. The purpose of the second study was to determine how much stocking would be improved if chopping preceded regeneration with the scarifier-seeder.

METHODS

For the first study, a 3-row scarifier-seeder was modified by adding an 18-in. diameter roller behind the center set of scarifier teeth. The roller was mounted on a pivot so it followed the contour of the scarified spot, packing the soil after the seed had been deposited. A 2-row machine was modified by welding ¼-in. thick straps of metal between scarifier teeth placed at the midpoint of the teeth (Figure 1) to reduce the depth of penetration—and thus the relative slope—of the scarified spot.

Study areas are on the Lake George district of the Ocala National Forest, in central Florida. Six areas, ranging in size from 18 to 80 ac, were randomly selected from 40 areas to be regenerated for testing of the modified machines. The sites were treated in December with both machines adjusted to make about 975 scarified spots per ac and to drop an average of 9 seeds on the upper portion of each spot. The seed used was extracted from general forest cone collections, was treated with Arasan and aluminum powder, and had a germination rate of 80%.

On all sites, the three-row and the two-row machines operate adjacently, creating a row of packed spots, a row of standard (i.e., control) spots, and a row of shallow spots in sequence. Three sample plots of each treatment type were randomly located on each of the six sites after sowing (see Fig. 2). A sample plot consisted of a row of 25 scarified spots of each of the three treatments located adjacently. At 2 and 5 months after sowing, the sample plots were checked to determine the number of stocked spots and the number of seedlings, by location on the spot, for each different treatment. Locations were recorded as upper, middle, and lower based on the division of each scarified spot into thirds.

Three areas with medium- to heavy-brush competition were selected for the second study. Each area was divided into two parts: one side receiving a single pass with a double-drum chopper prior to seeding and the other serving as the control. Both sides of all three sites were seeded in December using an unmodified 3-row machine. The seeding rate, spot spacing, and seed were the same as used in the first study. Three replications of 10 scarified spots each were randomly selected on each half of all sites. These were checked 5 months after sowing for the number of stocked spots and the total number of seedlings. Treatment comparisons in both studies were made using analysis of variance techniques.

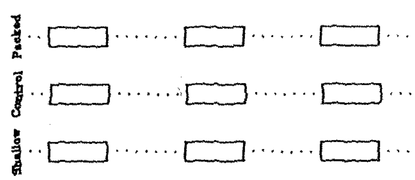

Figure 2. Study schematic.

RESULTS

The type of spot had no effect on percent stocking, which averaged 22% for all treatments 2 months after seeding (Table 1). Thus, neither packing the soil nor reducing the depth of the scalp increased seed survival or initial germination. In May, 5 months after seeding, there were still no differences in stocking due to spot type, but the average stocking had increased to 33% for all treatments. Thus, if weather conditions are favorable, some increase in stocking can be expected from delayed germination after the peak germination period has occurred. Although there was no overall difference attributable to type of spot, Table 1 indicates there was significantly less variation site-to-site with shallow spots.

Even though spot type did not affect stocking or total number of seedlings, it did affect seedling location on the spot (Table 2). Both the shallow and the packed treatments had more seedlings on the upper portion of the microsite than did the standard treatment. Since all treatments deposited seeds at a similar position, this is attributed to less seed movement when the soil is packed or the degree of slope is reduced.

Past experiences with broadcast seeding indicated that chopping prior to direct seeding would be beneficial, but the amount of gain possible when used with the scarifier-seeder had not been previously determined. In the operational trials of the second study, chopping increased average stocking from 10 to 47% (Table 3). A 25% stocking with 975 spots per ac equals 244 well-distributed trees per ac, which is the minimally acceptable level for Ocala sand pine. Thus, all of the sites were failures on nonchopped portions, and all were successful on the chopped areas. The abnormally low amount of rainfall (Table 4) received during December when seeding was done was a major factor in the poor stocking on nonchopped areas. Stocking would have been higher with normal levels of precipitation.

Table 1. Effect of spot type on stocking of Ocala sand pine 2 and 5 months after direct seeding with a scarifier-seeder.

Type of spot	Stocking by study area 1	2	3	4	5	6	Average stocking[1]
	(%)						
	2 months (February)						
Packed	9	28	36	1	40	15	22
Standard	4	59	35	8	0	23	21
Shallow	23	16	7	24	35	27	22
	5 months (May)						
Packed	24	48	52	9	55	27	36
Standard	15	68	48	17	0	45	32
Shallow	32	27	23	44	40	32	33

[1] There was no significant difference in mean stocking at 2 or at 5 months.

DISCUSSION

Past work (Winston and Schnieder 1977, Damme 1988) indicates that compaction of the seeding microsite would increase stocking on areas sown with scarifier-seeder equipment. In those trials, however, seeds were sown by hand on spots formed by the scarifier-seeder. In the present operational test of soil packing with the machine sowing the seed on the spot ahead of the packer, no increase in stocking was found. The only benefit noted from packing the soil was a reduction in the movement of seeds prior to germination. The packing wheel employed succeeded in leveling and stabilizing the seedbed, but it also contributed to operational "down time" by occasionally catching debris, which necessitated stopping to remove. In addition, the apparatus received considerable punishment, and some delays were caused by mechanical failure of the packing attachment. Thus, the addition of a packing wheel to the scarifier-seeder is not recommended.

Modifying the machine to reduce penetration of the scalping teeth—thereby reducing depth and slope of the scarified spot—also did not improve average stocking, but it did reduce the movement of seeds prior to germination. Location is quite critical for good initial growth of seedlings. Numerous personal observations indicate seedlings do best when growing near the hinge area where the soil from the pit is turned over onto the surface. Seeds placed above this point on top of the mound often do not germinate, or if they do the seedlings die because of dry soil and air pockets from the debris under the overturned soil. Near the hinge point seedlings are close enough to take advantage of the nutrients released by the decom-

Table 2. Effect of spot type on the location of Ocala sand pine seedlings 5 months after direct seeding with a scarifier-seeder.

Seedling location on spot	Number of seedlings: Packed	Standard	Shallow
Top	188a[1]	109b	171a
Middle	83a	176b	68a
Totals	271	285	239

[1] Within a row, values not followed by the same letter are significantly different at the 0.05 level.

Table 3. Ocala sand pine stocking on areas direct seeded with a scarifier-seeder with or without double-chopping.

	Stocking: Double-chopped	No site preparation
	(%)	
Area 1	63	17
Area 2	50	7
Area 3	27	7
Average	47	10

Table 4. Rainfall during critical months for seeding trials on the Ocala National Forest of central Florida, compared to normal rainfall.

Month	Normal[1]	Study period[2]
	.... (in.)	
October	3.6	1.9
November	1.9	6.2
December	2.4	0.5
January	2.5	7.1
February	2.9	3.7
March	3.1	6.8

[1] USDC 1970.
[2] Recorded at the seed orchard on the Ocala National Forest.

position of the incorporated organic matter—a very important source of nutrition on these sterile sand soils—without having to cope with poor rooting conditions. Therefore, seeds should stay where they are placed. And modification to reduce the slope of the scarified spot is superior to the packing wheel for doing this because this modification of the equipment caused no operational problems or breakage and should require slightly less horsepower to operate.

Lowest stocking in shallow spots (area number 3) was caused by poor scarification and poorly formed spots due to the heavy brush on the site. On areas like this the standard machine will do a better job of penetrating and tearing up the root mat of the competition. However, as shown by the second study, chopping prior to seeding would be highly desirable on such sites. In fact, that study indicates all sites with brush competition would benefit from chopping prior to direct seeding with the scarifier-seeder. Although all would likely benefit in increased stocking, not all areas require chopping for acceptable stocking levels—as shown by the five areas with shallow spots—which were successful without it. In addition, since broadcast seeding is done with a machine attached to the equipment pulling the chopper, if areas have to be chopped, the scarifier-seeder method loses most of its advantages over broadcast seeding. The extra expense of a two-pass operation would have to be offset by improved spacing and the use of less seed, ¼ vs. ½ lb for the scarifier-seeder and the broadcast seeder, respectively. At present the best solution would be to develop some measure of brush competition for deciding when chopping is needed for successful regeneration. Areas with significant brush competition could be chopped and broadcast while other areas would be regenerated with the scarifier-seeder. □

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